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PHYTOTOXICOLOGY SURVEY REPORTS

CYANAMID - NIAGARA FALLS,

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PHYTOTOXICOLOGY SURVEY REPORTS: CYANAMID - NIAGARA FALLS

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PHYTOTOXICOLOGY SURVEY REPORTS: CYANAMID - NIAGARA FALLS

1990 AND 1991

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Abstract

Phytotoxicology Survey Reports: Cyanamid - Niagara Falls, 1990 and 1991.

This report binds two separate reports under one cover. The Phytotoxicology section conducted a vegetation and soil assessment survey in the vicinity of Cyanamid in Niagara Falls in 1990. The survey was repeated (vegetation only) in 1991. Tree foliage was examined for symptoms of air pollution injury and collected for chemical analysis. No air pollution injury symptoms were observed on vegetation either at the sample sites, or elsewhere in the vicinity of Cyanamid. Soil molybdenum concentrations exceeded the ULN guideline at two sample sites in 1990, and may be associated with historical deposition. Foliar concentrations did not exceed ULN guidelines in either sample years. The Cyanamid facility is not a significant source of any of the 16 inorganic elements tested in 1990 and 1991.

Table of Contents

Abstract 1

Table of Contents 2

List of Tables 3

Report 1: Phytotoxicology Assessment Survey in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1990. **4**

Introduction 5

Analytical Results 6
  Vegetation 6
  Soils 6

Electrical Conductivity and pH Test Results 7

Summary 7

Phytotoxicology Vegetation and Soil Surveillance Sites in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1990 15

Derivation and Significance of the MOEE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines 16

Report 2: Phytotoxicology Assessment Survey in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1991 **17**

Introduction 18

Field Inspection 18

Results/Discussion 19

References 20

Derivation and Significance of the MOEE Phytotoxicology "Upper Limits of Normal" Contaminants Guidelines 29

List of Tables

Report 1: Phytotoxicology Assessment Survey in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1990.

Table 1: Observational Notes of Foliage Examined in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1990

Table 2: Concentrations of 16 Inorganic Elements Detected in Surveillance Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1990

Table 3: Concentrations of 16 Inorganic Elements Detected in 0-5 cm and 5-10 cm Soil Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1990

Table 4: pH and Electrical Conductivity (EC) of Soils Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1990

Report 2: Phytotoxicology Assessment Survey in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1991

Table 1: Titanium Concentrations in Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls 1990 & 1991

Table 2: Sulphur Concentrations in Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls 1990 & 1991

Table 3: Copper Concentrations in Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls 1990 & 1991

Table 4: Nickel Concentrations in Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls 1990 & 1991

Table 5: Iron Concentrations in Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls 1990 & 1991

Table 6: Zinc Concentrations in Foliage Collected in the Vicinity of Cyanamid (Welland Party), Niagara Falls 1990 & 1991

Table 7: Lead Concentrations in Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls 1990 & 1991

Table 8: Cadmium Concentrations in Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls 1990 & 1991

Report 1

Phytotoxicology Assessment Survey in the Vicinity of Cyanamid (Welland Plant) Niagara Falls - 1990

Phytotoxicology Assessment Survey in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1990

Introduction

At the request of the Ministry's Welland District Office, the Phytotoxicology Section initiated a surveillance investigation of vegetation and soil in the vicinity of Cyanamid (Welland Plant) in Niagara Falls. The company operates a large complex which produces phosphene, dicyanadiamide and hydrogen cyanamid solutions.

The purpose of the Phytotoxicology survey was to examine nearby foliage for possible evidence of air pollution injury and to sample vegetation and soils to determine the impact of emissions from the Cyanamid plant on the terrestrial environment.

Phytotoxicology Surveillance Activities

On 12 September 1990, Mr. George Vasiloff of the Phytotoxicology Section visited the Cyanamid area and established a network of 9 vegetation and 5 soil surveillance sites. Wherever possible, site locations were selected to provide representation on all sides of the large factory complex. The survey site locations are shown in the attached figure.

With the exception of Sites 1 and 3, elm vegetation was available at all survey locations for observational and sampling purposes. At Site 1, only green ash was suitable for observation and sampling purposes. Site 3 was an open lawn area and no vegetation whatsoever was present. At each location, foliage on tree crowns facing the Cyanamid plant was examined for evidence of air pollution injury and surface particulate. A summary of the observational notes is provided in Table 1. As the notes indicate, no vegetation injury attributable to air pollution was observed at any of the 9 survey sites. Although the cause of the foliar injury noted at Site 8 is unknown, the symptoms were similar to those induced by drought stress rather than by pollution. No evidence of surface particulates was noted on foliage at any of the survey locations. Following the observational aspect of the survey, triplicate samples of the examined foliage were collected for chemical analysis.

Soils were collected for chemical analysis at 2 sites upwind of the plant (1 & 6) and at 2 sites (3 & 5) downwind. During the growing season, and times of the year when the ground is not snow-covered, the prevailing wind is from the west or southwest. Each site was undisturbed and well exposed. Duplicate samples of 0-5 cm and 5-10 cm soil were obtained at each site, using a clean, standard soil core borer (Oakfield Sampler). Sampling at each site was done in a random manner following an imaginary "X" pattern. Each of the duplicate samples contained no fewer than 25 individual soil cores. During the vegetation and soil collection process, new vinyl gloves were worn by the investigator to prevent sample contamination.

Vegetation and soil samples were returned to the Phytotoxicology laboratory in Toronto and submitted for processing. Vegetation samples were processed as not-washed according to a standard procedure. Similarly, soil samples were processed using a standard procedure developed for this medium. Processed vegetation and soil samples were then submitted to the Ministry's Inorganic Trace Contaminants laboratory to be analyzed for copper, nickel, iron, zinc, lead, cadmium, sodium, cobalt, molybdenum, manganese, chromium, aluminum, strontium, vanadium, titanium and sulphur. Electrical conductivity and pH tests for the soils were also requested.

Analytical Results

Vegetation

Concentrations of 16 inorganic elements detected in survey foliage are summarized in Table 2. Each value in the table represents the mean of triplicate sample analysis. Phytotoxicology Upper Limit of Normal (ULN) guidelines for elements in rural foliage are listed at the base of the table. The rationale for the derivation and use of the ULN guidelines is provided in the appendix.

Concentrations of sulphur, copper and zinc found in foliage at Site 1 were slightly elevated compared to concentrations of the elements found at other survey and control locations. It is unlikely that the elevated sulphur, copper and zinc concentrations found in the vegetation at Site 1 are related to industrial emissions because concentrations were not similarly or proportionately elevated at Site 8, which is only about 150 metres farther from Cyanamid. Similarly, there was no concentration gradient relative to distance or direction from the source. Concentrations of all 16 elements were well below the ULN guidelines at all survey sites.

Soils

Analytical results for both 0-5 cm and 5-10 cm soils collected at 4 sites in the vicinity of the Cyanamid plant and the control site, are summarized in Table 3. Each value in the table represents the mean of duplicate sample analysis. The rationale for the derivation and use of the ULN guidelines for 0-5 cm rural soils (listed at the base of the table) is provided in the appendix. No guidelines have been developed for 5-10 cm soils.

Of the 16 elements examined in 0-5 cm soil, concentrations of sulphur, manganese and molybdenum detected at Site 1 and molybdenum at Site 3, were above ULN guidelines for rural soil. Concentrations of the remaining elements were similar to those at the other survey and control locations.

Manganese concentrations found naturally in soil, can vary considerably. For this reason, the excessive concentration of the element detected at Site 1 does not necessarily indicate that Cyanamid was the source. The source of the excessive sulphur concentration found in the 0-5 cm soil at Site 1 may be the Cyanamid plant, but this is not certain.

Based on the distance and direction from Cyanamid, soil at Site 3 should be the most contaminated because it is both the closest and the most directly downwind. However, as with the vegetation data, there is no contamination gradient in the soil; therefore, Cyanamid is not ~~likely the source of the marginally elevated sulphur and manganese concentrations~~ detected at Site 1. In contrast, unlike sulphur and manganese, background molybdenum concentrations are well defined (and low), and so concentrations in exceedence of the ULN at the two sample sites closest to Cyanamid suggests this facility may be a source of molybdenum emissions.

Also, at Site 1 the concentration of sodium detected in the 0-5 cm soil was elevated compared to other survey and control locations. Since this site is adjacent to a well-travelled road, the elevated sodium value may reflect the use of road salt and not sodium emissions from the Cyanamid plant.

Electrical Conductivity and pH Test Results

Tests for pH measure soil acidity and alkalinity, whereas electrical conductivity (EC) tests determine the concentration of soluble salts in soil. High concentrations of salts in soil can prevent or delay germination of seeds and can kill established plants or seriously retard their normal growth.

The results of the pH and EC tests are summarized in Table 4. Both pH and EC values found in the survey soils were within an acceptable normal range. The pH and EC values should not be detrimental to the growth or development of most plants. The EC levels are moderately elevated at Site 1. This likely reflects the use of de-icing salt on Chippawa Creek Road and corroborates the elevated sodium level detected in soil at this site.

Summary

No visual evidence of air pollution injury or particulate deposition was observed on vegetation at any of the surveillance sites in the vicinity of the Cyanamid plant.

Of the 16 elements examined in foliage, none exceeded the ULN guidelines. Concentrations of sulphur, copper and zinc were elevated at Site 1 compared to other survey and control locations; however, based on the findings from other sites, it was unlikely that the elevated levels were related to emissions from the Cyanamid plant.

Sulphur, manganese and molybdenum concentrations in excess of ULN guidelines were detected in 0-5 cm soils at Site 1 and molybdenum at Site 3. The concentration of sodium at Site 1 was found to be elevated in relation to the other survey sites.

The excessive manganese concentration in the soil at Site 1 was attributed to natural occurrence rather than emissions from the plant. Depending on location and soil type, concentrations of this element can exceed the ULN guideline. The source for the excessive sulphur value is not known, but the elevated sodium value is attributed to the effects of road salt. Molybdenum detected in soil at Sites 1 and 3 may be source-oriented. If this is the case, the absence of any detectable foliar contamination would indicate that it is related more to historical emissions.

TABLE: 1 Observational Notes of Foliage Examined in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1990

Survey Site Number	Distance & Direction from Cyanamid	Vegetation Examined	Observations
1	0.3 km SSW	Manitoba maple	Herbicide-type injury on youngest foliage.
		Green ash	No visible foliar injury.
2	0.9 km WSW	Green ash	Foliar insect injury present.
		Elm	Foliar insect injury present.
		Basswood	Foliar insect injury present.
		Shagbark hickory	Foliar insect injury present.
		Raspberry	Foliage senescent.
3	0.25 km NE	Wild grasses	No visible foliar injury.
4	0.9 km NNE	Basswood	Foliar insect injury present.
		Elm	Foliar insect injury present.
5	2.1 km NE	Elm	Foliar insect injury present.
		Raspberry	No visible foliar injury.
6	2.0 km SW	Green ash	Foliar insect and disease injury present.
		Elm	Foliar insect injury present.
		Hawthorn	Foliar insect and disease injury present.
		Dogwood	No visible foliar injury.
7	3.7 km SW	Green ash	Foliar insect injury present.
		Sugar maple	No visible foliar injury.
		Elm	Foliar insect injury present.
8	0.45 km SE	Elm	2-10% terminal & marginal necrosis - possibly drought symptoms. Considerable foliar insect injury present.
		Black walnut	Foliage senescent.
		Shagbark hickory	Foliar insect injury present.
9	2.0 km NW	Elm	Foliar insect injury present.
		Green ash	Foliar insect injury present.
		Shagbark hickory	Foliar insect injury present.
		Wild cherry	No visible foliar injury.
		Pear	No visible foliar injury.

TABLE: 2 Concentrations of 16 Inorganic Elements Detected in Surveillance Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1990

Survey Site Number	Vegetation Sampled	Distance & Direction from Cyanamid	Elemental Values (ppm - dry wt)[1] Ti	S (%)	Cu	Ni	Fe	Zn	Pb	Cd
1	Green ash	0.3 km SSW	10	0.273	12	<3	150	31	<1	<0.10
2	Elm	0.9 km WSW	11	0.160	5	4	130	15	<1	<0.10
3	None Available	0.25 km NE	--	--	-	-	-	--	-	--
4	Elm	0.9 km NNE	13	0.130	7	4	170	14	<1	<0.10
5	Elm	2.1 km NE	12	0.097	4	3	150	17	<1	<0.10
6	Elm	2.0 km SW	8	0.133	4	<3	130	13	<1	<0.10
7 (Control)	Green ash	3.7 km SW	5	0.207	5	3	180	18	<1	<0.21
	Elm		8	0.080	5	3	127	14	<1	<0.10
8	Elm	0.45 km SE	16	0.113	5	3	157	23	<1	<0.10
9	Elm	2.0 km NW	25	0.123	6	3	220	12	<1	<0.10
Phytotoxicology Upper Limit of Normal (ULN) Guidelines for rural foliage.			NE	0.4%	20	5	500	250	30	1

[1] Mean of triplicate samples.

NE - ULN guideline has not been established for this element

Sulphur concentrations are precent (%).

cont'd....

TABLE: 2 (Cont'd)

Survey Site Number	Vegetation Sampled	Distance & Direction from Cyanamid	Elemental Values (ppm - dry wt)[1] Na	Co	Mo	Mn	Cr	Al	Sr	V
1	Green ash	0.3 km SSW	23	<0.3	<0.6	47	<0.7	68	107	<0.6
2	Elm	0.9 km WSW	33	<0.2	<0.6	35	<0.5	54	91	<0.6
3	None Available	0.25 km NE	--	-	-	--	-	--	--	-
4	Elm	0.9 km NNE	29	<0.2	<0.3	85	<1.5	92	65	<0.6
5	Elm	2.1 km NE	20	<0.4	<0.4	47	<0.5	83	123	<0.5
6	Elm	2.0 km SW	20	<0.2	<0.5	46	<0.6	53	83	<0.5
7	Green ash	3.7 km SW	17	<0.3	<1.0	46	<0.5	30	102	<0.5
(Control	Elm	3.7 km SW	32	<0.2	<0.2	119	<0.5	56	51	<0.5
8	Elm	0.45 km SE	34	<0.2	<0.2	63	<0.5	67	52	<0.5
9	Elm	2.0 km NW	32	<0.2	<0.4	49	<0.5	110	92	<0.6
Phytotoxicology Upper Limit of Normal (ULN) Guidelines for rural foliage.			50	2	1.5	NE	8	500	NE	5

[1] Mean of triplicate samples.

NE - ULN guideline has not been established for this element.

TABLE: 3 Concentrations of 16 Inorganic Elements Detected in 0-5 cm and 5-10 cm Soil Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1990

Survey Site Number	Sample Depth	Distance & Direction from Cyanamid	Elemental Values (ppm - dry wt)[1]							
			Ti	S (%)	Cu	Ni	Fe (%)	Zn	Pb	Cd
1	0-5 cm	0.3 km SSW	0.4	0.14	35	34	2.6	135	35	0.7
	5-10 cm		0.4	0.05	32	35	3.2	85	21	0.7
3	0-5 cm	0.25 km NE	0.4	0.08	22	23	1.7	180	54	0.2
	5-10cm		0.5	0.05	19	22	1.6	125	35	<0.1
5	0-5 cm	2.1 km NE	0.6	0.08	20	25	1.4	76	31	<0.1
	5-10 cm		0.6	0.05	17	20	1.5	55	20	<0.05
6	0-5 cm	2.0 km SW	0.6	0.04	13	24	2.0	76	19	<0.01
	5-10 cm		0.6	0.03	15	24	2.1	79	15	<0.05
7 (Control)	0-5 cm	3.7 km SW	0.6	0.05	24	39	2.4	130	30	0.6
	5-10 cm		0.6	0.03	20	25	2.9	95	15	<0.2
Phytotoxicology Upper Limit of Normal (ULN) Guidelines for 0-5 cm rural soil only.			NE	0.1%	60	60	3.5%	500	150	3

[1] Mean of Duplicate samples.

Underlined values are in excess of their respective ULN guidelines (0-5 cm).

Sulphur and iron results shown are in percent (%) - dry weight

cont'd....

TABLE: 3 (Cont'd)

Survey Site Number	Sample Depth	Distance & Direction from Cyanamid	Elemental Values (ppm - dry wt)[1]							
			Na	Co	Mo	Mn	Cr	Al (%)	Sr	V
1	0-5 cm	0.3 km SSW	295	17	9	730	32	2.2	86	44
	5-10 cm		370	15	6	700	36	2.6	70	50
3	0-5 cm	0.25 km NE	78	7	5	375	20	1.2	14	29
	5-10 cm		91	6	<2	320	19	1.6	17	31
5	0-5 cm	2.1 km NE	70	5	<1	185	25	2.1	44	32
	5-10 cm		65	5	<1	130	23	2.1	32	32
6	0-5 cm	2.0 km SW	67	8	<1	285	24	1.9	23	37
	5-10 cm		83	8	<1	270	25	2.1	22	41
7 (Control)	0-5 cm	3.7 km SW	60	9	2	490	37	2.8	28	40
	5-10 cm		66	8	1	205	34	3.2	18	43
Phytotoxicology Upper Limit of Normal (ULN) Guidelines for 0-5 cm rural soil only.			NE	25	2	700	50	NE	NE	70

[1] Mean of duplicate samples.

Underlined values are in excess of their respective ULN guidelines (0-5 cm).

Aluminum results shown are in percent (%) - dry weight.

TABLE: 4 pH and Electrical Conductivity (EC) of Soils Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1990

Survey Site Number	Sample Depth	pH	EC
1	0-5 cm	5.6	0.37
1	5-10 cm	6.5	0.29
3	0-5 cm	6.2	0.13
3	5-10 cm	5.1	0.16
5	0-5 cm	5.7	0.17
5	5-10 cm	5.8	0.12
6	0-5 cm	5.3	0.13
6	5-10 cm	5.5	0.11
7	0-5 cm	5.7	0.02
7	5-10 cm	5.8	0.10

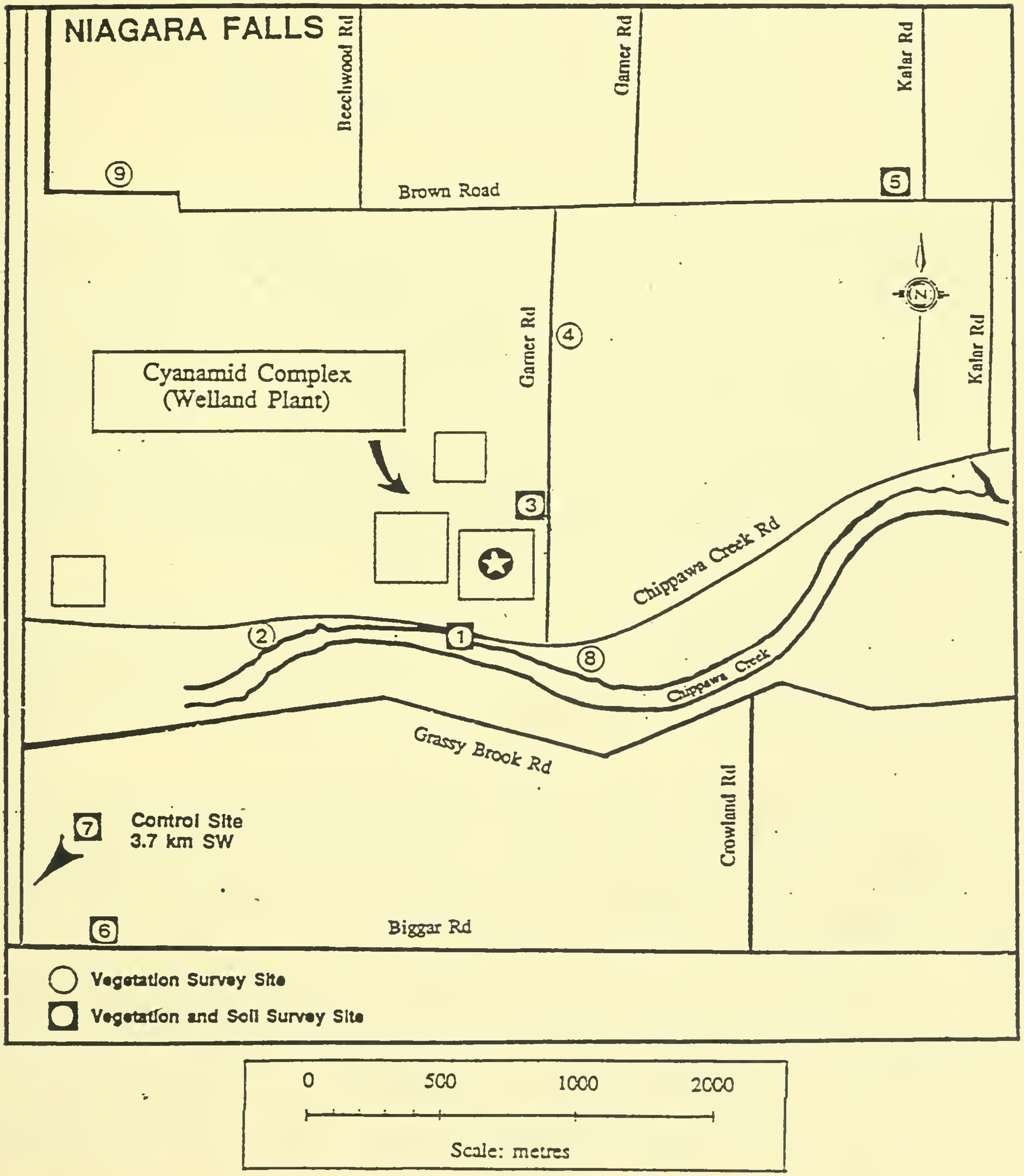
Electrical Conductivity is millisiemens/cm.

Data are average of duplicate results.

Interpretation of Electrical Conductivity

Conductivity Reading	Rating	Plant Response
0 - 0.25	L	Suitable for most plants.
0.26 - 0.45	M	Suitable for most plants.
0.46 - 0.70	H	May reduce emergence and cause slight to severe damage to salt sensitive plants.
0.71 - 1.00	E	May prevent emergence and cause slight to severe damage to most plants.
1.00	E	Expected to cause severe damage to most plants.

Phytotoxicology Vegetation and Soil Surveillance Sites
in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1990



Derivation and Significance of the MOEE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines.

The MOEE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a pollution source. Urban ULN guidelines are based on samples collected from urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (reference: *Ontario Ministry of the Environment. 1989. Ontario Ministry of the Environment "Upper Limit of Normal" Contaminant Guidelines for Phytotoxicology Samples. Phytotoxicology Section, Air Resources Branch: Technical Support Sections NE and NW Regions, Report No. ARB-138-88-Phyto. ISBN: 0-7729-5143-8.*). Chemical analyses were conducted by the MOEE Laboratory Services Branch.

The ULN is the arithmetic mean plus three standard deviations of the suitable background data for each chemical element and parameter. This represents 99% of the sample population. This means that for every 100 samples that have not been exposed to a pollution source, 99 will fall within the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOEE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.

Report 2

Phytotoxicology Assessment Survey in the Vicinity of Cyanamid (Welland Plant) Niagara Falls - 1991

Phytotoxicology Assessment Survey in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1991

Introduction

At the request of the Ministry's Welland District Office, the Phytotoxicology Section initiated a surveillance investigation in 1990 of vegetation and soil in the vicinity of Cyanamid (Welland Plant) in Niagara Falls. The company operates a large complex that produces phosphene, dicyanadiamide and hydrogen cyanamid solutions.

The purpose of the Phytotoxicology survey was to examine nearby foliage for possible evidence of air pollution injury and to sample vegetation and soils to determine the impact of emissions from the Cyanamid plant on the terrestrial environment.

During the course of the 1990 survey, no evidence of air pollution injury or particulate deposition was observed on vegetation at any of the survey sites in the vicinity of Cyanamid. Of the 16 elements examined in sampled foliage, none exceeded ULN guidelines. Apart from manganese and sodium, concentrations in soil of the remaining 14 elements were below ULN guidelines. The excessive concentrations of manganese and sodium found in soil at some sites were not attributed to Cyanamid emissions[1].

Field Inspection

On 23 September 1991, Mr. George Vasiloff of the Phytotoxicology Section visited the Cyanamid area and conducted a vegetation survey at 8 of the 9 sites established in 1990 and at a new site (10) selected in 1991. No vegetation was present at Site 3 for examination or sampling in 1990 or 1991. All site locations were selected in order to provide representation on all sides of the large factory complex. The survey site locations are shown in the attached figure.

With the exception of Site 1, elm vegetation was available at all locations for observational and sampling purposes. At Site 1, both green ash and Manitoba maple were sampled in 1991. At each survey site, foliage of tree crowns facing the Cyanamid plant was examined for evidence of air pollution injury and surface particulate. No evidence of surface particulates was noted on foliage at any of the survey locations. The foliage, however, was senescent and, therefore, it was not evaluated for the presence of air pollution symptoms.

Following the observational aspect of the survey, triplicate samples of the examined foliage were collected for chemical analysis. New vinyl gloves were worn by the investigator at each site during the sampling process to avoid sample contamination.

Collected samples were returned to the Phytotoxicology laboratory in Toronto and submitted for processing. The vegetation was processed as not-washed according to a standard procedure. Prepared samples were then submitted to the Ministry's Inorganic Trace Contaminants laboratory to be analyzed for titanium, sulphur, copper, nickel, iron, zinc, lead, cadmium, sodium, cobalt, molybdenum, manganese, chromium, aluminum, strontium and vanadium.

Results/Discussion

Concentrations of 16 inorganic elements detected in the 1990 and 1991 survey foliage appear in Tables 1-16. Each value in the table represents the mean of triplicate sample analysis. Phytotoxicology Upper Limit of Normal (ULN) guidelines for elements in rural foliage appear at the base of each table. The rationale for the derivation and use of the ULN guidelines is provided in the appendix. No guidelines have been established for titanium, manganese or strontium.

Although there were some minor fluctuations, concentrations of all 16 elements found in the 1991 foliage were similar to those of 1990. In both survey years, concentrations of all elements were at or below ULN guidelines in the sample foliage with one exception. That exception was nickel which marginally exceeded the ULN in elm foliage collected at Site 4 in 1991. Copper and zinc concentrations in the 1990 and 1991 foliage were slightly more elevated at Site 1 than at other sites and the control. However, it is unknown if Cyanamid is a potential source of these elements. With respect to elements such as nickel, lead, cadmium, cobalt, molybdenum, chromium and vanadium, many values found were at a measurable trace amount or below the analytical detection limit. With the possible exception of copper and zinc, there is no apparent pattern of higher elemental concentrations at sites close to the plant in either the 1990 or 1991 analytical results.

Conclusions

There was no evidence of particulate deposition on the survey vegetation examined in the vicinity of Cyanamid in 1991. Due to the early onset of senescence, foliage could not be evaluated for air pollution injury symptoms.

Of the concentrations found in the 16 elements examined in the 1991 foliage, only nickel at one site in 1991 exceeded the ULN guidelines. Values of seven elements in both the 1990 and 1991 foliage were at a measurable trace amount or below the analytical detection limit. Slightly elevated concentrations of copper and zinc were present in foliage at Site 1, but it cannot be determined with confidence that they are the result of industrial emissions.

Based on the 1990 and 1991 analytical results, no depositional pattern associated with the Cyanamid plant was evident. It is concluded, therefore, that Cyanamid does not appear to be a significant source of any of the 16 elements examined.

Since the survey did not document any contaminant problem in the vicinity of the Cyanamid operation, it is recommended that no further vegetation surveys be carried out for at least 5 years, unless there is more direct evidence of a problem, process change and/or abatement activity at the facility.

References

1 - **Phytotoxicology Assessment Survey in the Vicinity of Cyanamid (Welland Plant), Niagara Falls - 1990.** Report No. ARB-170-91-Phyto. Ontario Ministry of the Environment, Toronto.

TABLE: 1 Titanium Concentrations* in Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls 1990 & 1991

Survey Site Number	Direction & Approximate Distance from Cyanamid	Vegetation Species Sampled	1990	1991
1	0.3 km SSW	green ash	10	10
		Manitoba maple	NR	10
2	0.9 km WSW	elm	11	11
4	0.9 km NNE	elm	13	14
5	2.5 km NE	elm	12	20
6	2.5 km SW	elm	8	15
7**	3.7 km SW	green ash	5	8
		elm	8	11
		Manitoba maple	NR	11
8	0.45 km SE	elm	16	15
9	2.5 km NW	elm	25	11
10	2.5 km NW	elm	ND	16
ULN			NG	NG

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.
NG - ULN not established.

TABLE: 2 Sulphur Concentrations* in Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls 1990 & 1991

Survey Site Number	Direction & Approximate Distance from Cyanamid	Vegetation Species Sampled	1990	1991
1	0.3 km SSW	green ash	0.3	0.2
		Manitoba maple	NR	0.1
2	0.9 km WSW	elm	0.2	0.1
4	0.9 km NNE	elm	0.1	0.1
5	2.5 km NE	elm	0.1	0.1
6	2.5 km SW	elm	0.1	0.1
7**	3.7 km SW	green ash	0.2	0.3
		elm	0.1	0.1
		Manitoba maple	NR	0.1
8	0.45 km SE	elm	0.1	0.1
9	2.5 km NW	elm	0.1	0.1
10	2.5 km NW	elm	NR	0.1
ULN			0.4%	0.4%

*percent, dry weight, mean of triplicate samples and analysis.
**control location.
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

TABLE: 3 Copper Concentrations* in Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls 1990 & 1991

Survey Site Number	Direction & Approximate Distance from Cyanamid	Vegetation Species Sampled	1990	1991
1	0.3 km SSW	green ash	12	10
		Manitoba maple	NR	4
2	0.9 km WSW	elm	5	7
4	0.9 km NNE	elm	7	6
5	2.5 km NE	elm	4	5
6	2.5 km SW	elm	4	5
7**	3.7 km SW	green ash	5	7
		elm	5	5
		Manitoba maple	NR	5
8	0.45 km SE	elm	5	4
9	2.5 km NW	elm	6	5
10	2.5 km NW	elm	NR	7
ULN			20	20

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

TABLE: 4

Nickel Concentrations* in Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls 1990 & 1991

Survey Site Number	Direction & Approximate Distance from Cyanamid	Vegetation Species Sampled	1990	1991
1	0.3 km SSW	green ash	3T	2T
		Manitoba maple	NR	2T
2	0.9 km WSW	elm	4	5
4	0.9 km NNE	elm	4	6
5	2.5 km NE	elm	3	4
6	2.5 km SW	elm	2T	4
7**	3.7 km SW	green ash	3	2T
		elm	3	3
		Manitoba maple	NR	1T
8	0.45 km SE	elm	3	4
9	2.5 km NW	elm	3	5
10	2.5 km NW	elm	NR	4
ULN			5	5

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
T - a measurable trace amount, interpret with caution.
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.
Underline values exceed ULN guideline.

TABLE: 5 Iron Concentrations* in Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls 1990 & 1991

Survey Site Number	Direction & Approximate Distance from Cyanamid	Vegetation Species Sampled	1990	1991
1	0.3 km SSW	green ash	150	147
		Manitoba maple	NR	156
2	0.9 km WSW	elm	130	143
4	0.9 km NNE	elm	170	133
5	2.5 km NE	elm	150	160
6	2.5 km SW	elm	130	203
7**	3.7 km SW	green ash	180	133
		elm	127	137
		Manitoba maple	NR	130
8	0.45 km SE	elm	157	180
9	2.5 km NW	elm	220	237
10	2.5 km NW	elm	NR	177
ULN			500	500

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

TABLE: 6 Zinc Concentrations* in Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls 1990 & 1991

Survey Site Number	Direction & Approximate Distance from Cyanamid	Vegetation Species Sampled	1990	1991
1	0.3 km SSW	green ash	31	29
		Manitoba maple	NR	15
2	0.9 km WSW	elm	15	13
4	0.9 km NNE	elm	14	12
5	2.5 km NE	elm	17	17
6	2.5 km SW	elm	13	11
7**	3.7 km SW	green ash	18	11
		elm	14	15
		Manitoba maple	NR	16
8	0.45 km SE	elm	23	19
9	2.5 km NW	elm	12	12
10	2.5 km NW	elm	NR	13
ULN			250	250

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

TABLE: 7 Lead Concentrations* in Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls 1990 & 1991

Survey Site Number	Direction & Approximate Distance from Cyanamid	Vegetation Species Sampled	1990	1991
1	0.3 km SSW	green ash	1T	0.9T
		Manitoba maple	NR	2T
2	0.9 km WSW	elm	<1T	1.2T
4	0.9 km NNE	elm	<1T	0.6T
5	2.5 km NE	elm	1T	1.2T
6	2.5 km SW	elm	<1T	1.5T
7**	3.7 km SW	green ash	<1T	1T
		elm	DL	0.8T
		Manitoba maple	NR	0.9T
8	0.45 km SE	elm	DL	0.9T
9	2.5 km NW	elm	DL	1.9T
10	2.5 km NW	elm	NR	1.1T
ULN			30	30

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
T - a measurable trace amount, interpret with caution.
DL - below analytical detection limit.
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

TABLE: 8

Cadmium Concentrations* in Foliage Collected in the Vicinity of Cyanamid (Welland Plant), Niagara Falls 1990 & 1991

Survey Site Number	Direction & Approximate Distance from Cyanamid	Vegetation Species Sampled	1990	1991
1	0.3 km SSW	green ash	DL	DL
		Manitoba maple	NR	DL
2	0.9 km WSW	elm	DL	DL
4	0.9 km NNE	elm	DL	DL
5	2.5 km NE	elm	DL	DL
6	2.5 km SW	elm	DL	DL
7**	3.7 km SW	green ash	0.4T	DL
		elm	DL	0.2T
		Manitoba maple	NR	DL
8	0.45 km SE	elm	DL	DL
9	2.5 km NW	elm	DL	DL
10	2.5 km NW	elm	NR	DL
ULN			1	1

*ug/g, dry weight, mean of triplicate samples and analysis.
**control location.
T - a measurable trace amount, interpret with caution.
DL - below analytical detection limit.
NR - no results, analysis not conducted.
ULN - Phytotoxicology Upper Limit of Normal guideline, see appendix.

Derivation and Significance of the MOEE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines.

The MOEE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a pollution source. Urban ULN guidelines are based on samples collected from urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (reference: *Ontario Ministry of the Environment. 1989. Ontario Ministry of the Environment "Upper Limit of Normal" Contaminant Guidelines for Phytotoxicology Samples. Phytotoxicology Section, Air Resources Branch: Technical Support Sections NE and NW Regions, Report No. ARB-138-88-Phyto. ISBN: 0-7729-5143-8.*). Chemical analyses were conducted by the MOEE Laboratory Services Branch.

The ULN is the arithmetic mean plus three standard deviations of the suitable background data for each chemical element and parameter. This represents 99% of the sample population. This means that for every 100 samples that have not been exposed to a pollution source, 99 will fall within the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOEE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.